Effect of increasing greenhouse gases on Indian monsoon rainfall as downscaled from the ECHAM coupled model

S.V. Singh * and H.V. Storch **

* Indian Institute of Tropical Meteorology , Pune-8

** Max Planck Institute fur Meteorology , Hamburg

Extended Abstract

1. Introduction

It is more or less accepted that the increasing anthropogenic gases will result in global warming through greenhouse effect.The major influence of this will be felt in the form of ice melts and rising sea levels. The influence on the regional climates , like monsoons is not very clear. Since the monsoons arise due to surface heating, one would expect that the global warming will lead to more vigorous monsoons (Gerald Meehl , this volume)

The expected change in a climate parameter can be studied by analysing the historical data and then extrapolating that in time. Alternatively, we can use the state of the art coupled GCMs which are able to simulate the earth's climate with reasonable accuracy. Both methods have some limitations. The first method cannot adequately consider the nonlinearity and the second method may not be efficient for regional scales. In order that the projections can be trusted , the regional features should be well simulated. None of the current models are able to simulate the Indian Monsoon satisfactorily. Therefore it is desirable to infer the expected change in monsoon from other large and near global scale features which are better simulated. This approach which depends on the concurrent association between large scale modelled feature and a regional scale is known as Downscaling after Storch et al. (1993) and is adopted here to project the Indian monsoon rainfall for next 100 years from the ECHAM T21 coupled model.

2.Method

2.1 Identification of climatic element and region.

Before the downscaling is applied for projecting a regional climate, we ought to examine what features of the model are well simulated. The climatic element to be used should have long period records, such that the relationship between it and the monsoon rainfall can be developed from sufficiently long historical data. Therefore the surface pressure is the obvious candidate. The Indian monsoon rainfall shows highly significant correlation over a wide region extending from India to the Caspian Sea. The correlation is lower than -.5 over the area from 50-80 E and extending upto 60 N latitude.

2.2 Features of simulated pressure and rainfall

ECHAM T21 coupled model is able to simulate several features of Indian monsoon satisfactorily,like the mean rainfall and pressure,the annual cycle,the lower and upper level winds,variability of onset dates etc. (c. f. M.Lal(ed.) Global warming, 1993).However the lowest pressure in the monsoon trough is obtained over Tibetan plateau as against over Arabia observed in climatic data. Also the highest rainfall is found over peninsula around 15 o N Lat. against the observed over the Central plateau. Amongst other deficiencies , the teleconnection between rainfall and extratropical pressure is not simulated well. But the concurrent correlation between pressure and rainfall south of 20 oN is as good as in observed data. Besides certain multivariate features of pressure and rainfall fields like Empirical orthogonal functions and Canonical correlation patterns, resemble well with the observed data. Therefore we have employed the canonical correlation patterns to establish the relationship in the observed data and to project the anticipated climatic change.

3.Results

Canonical correlations are computed between the seasonal pressure and rainfall fields. For rainfall India is divided into 52 2.5oLat/Long. blocks and the surface pressure extends from 20 - 60 oN and 40 -120 oE. The first two canonical correlations are found significant and shows correlation of .6 to .7 over different data periods. The variance explained for individual fields varies from 10-20 %. The reconstructed all India rainfall from the first canonical correlation for the period 1901 - 1985 brings out the long term trend in the rainfall observed during the current century. This feature explains about 10 % of the total interannual variance.

The canonical correlation patterns obtained in observed data are then used to project the monsoon rainfall from the simulated runs. For this purpose the preindustrial run of the coupled ECHAM T21 model, for 189 years is used. The CO2 concentration in this run is increased as per scenario 'A' of IPCC. The control run is used to determine the normal state. It is observed that the rainfall increases from beginning to about year 2050 after which it tends to stabilise. Shorter period cycles of about 40 years period can also be noted.

4. Conclusions

The extratropical pressure,particularly around Caspian sea, is significantly related with monsoon rainfall. There is common long period trend/cycle in the Eurasian pressure field and monsoon rainfall.

Though there are systematic errors in mean simulated field, the multivariate structure of pressure and rainfall fields are satisfactiroly simulated by ECHAM T21 coupled model

Both direct evaluation of model simulations and indrectly downscaled results suggest that the increase in CO2 as per IPCC scenario 'A' will increase the monsoon rainfall by about 7% in 50-60 years near about the doubling of CO2.

Future attempts should be directed towards removal of systematic bias of models, testing with higher resolution models and longer runs.

References:

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